

Earth & Environmental Sciences Division

News, Views & EEScience

Disclaimer: this monthly update is intended for internal distribution within the Earth and Environmental Sciences Division at Los Alamos National Laboratory and must not be distributed outside of LANL.

Safety

A Message from Jeff

Jeff Hansen, Division ES&H Officer,
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Parking and Safety

There appears to be no let up for those of us who park our vehicles at TA-3. As long as new buildings are being built in existing parking areas the possible areas left to park just get smaller or further away. Early seems to be the only key. Parking enforcement is spotty, at best, and is usually based on whether specific officers are available from PTLA, an organization chronically short of people. Lately, I have been getting e-mail and or voice messages that a parking problem has developed and there is a potential safety issue (blocked access, fire hydrants, etc.). This is a time critical issue and if I am not around no one knows about the problem until I see/hear the message. It is advisable that a contact be made directly to **Rebecca Rodriguez of S-OSI, 665-3505**. If the caller can identify the vehicle license number and description, parking issue, and the location it may help identify the culprit and get them moved. This does not guarantee that someone will be there with a ticket book. The blocked fire hydrant or access can cause the offender to be towed. In any case, the route is to S-OSI. Be advised that this group in S Division is rumored to be on the list to be reorganized but in the mean time they are my contact for parking issues

More on Safety

Note from **Paul**: I am reliably informed that the Laboratory will soon start construction on a new parking structure at TA-3 near the Warehouse, SM-30. This is in the vicinity of our Computing Facility, SM-31.

Security

An Ear on the LIR from Tony

Tony Montoya, Acting Division Security Officer (DSO), 7-8065, antonio@lanl.gov.

As you know, we have been given a deadline to come write an **Activity Security Plan** based on the security LIRs; the Activity Security Plan is now in "draft" form and has been sent to the EES group leaders for comment.

More on Security from Paul

Classification procedures for documents have changed with the addition of a requirement for a line manager to certify compliance with "integrity in research requirements". Also, there are revised and new classification guides in several areas, including the main guide (LA-4000) and guidance on radiological dispersal devices, chemical and biological weapons, and others. For more information, see: <http://int.lanl.gov/security/classification/> or consult with your friendly local **Authorized Derivative Classifiers** - Naomi Becker and Jim Aldrich, EES-6; Chris Bradley, Rod Whitaker, Wendee Brunish, and Steve Taylor, EES-11; and Jerri McTaggart, EES-12.

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News from the Student Ombudsman, Liaison

Alexis Lavine, EES Student Ombudsman,
alavine@lanl.gov, 7-3605

Mentors and Students - Attention

For those of you who will be bringing in students this summer, there are many new and improved resources for both mentors and students. We've also got a full schedule of events planned for students in EES (<http://ees5db.lanl.gov/studhandbook/events.html>). LANL Student Programs has been working hard to put together new internal and external student web pages and a mentor web page. The **internal student page** (<http://int.lanl.gov/education/>) can be linked to from the LANL home page. The mentor page (<http://int.lanl.gov/education/mentors/index.shtml>) can be accessed through the student page. Also, please guide incoming students to the external student page at <http://www.lanl.gov/education/>. The revised **EES Student and Mentor Guidelines** (<http://ees5db.lanl.gov/studhandbook/guidelines.html>) may also be helpful to mentors and students. Please feel free to contact **Alexis Lavine**, EES Division Student Liaison (alavine@lanl.gov, 7-3605) with any questions regarding students and mentors.

Welcome, Shurette Riley

Our new **HR Assistant** for EES Division has arrived, **Shurette Riley**; she's located in Building TA-3/215, Room 248. Her E-mail address is sriley@lanl.gov, and her phone number is 664-0617. Feel free to start contacting Shurette for any HR-related requests or questions you may have.

Shurette's education and experience in Human Resources will make her quite an asset to the division. She earned her B.B.A. in Human Resources Management from Anderson School of Management at UNM in

December 2001. Her most recent position was Human Resource Director at Las Cumbres Learning Services in Española. Prior to that, she held HR and administrative management positions in Santa Fe, Albuquerque, and Dallas. She also spent a year at Microsoft Corp. in Redmond, WA, as a Recruiting Assistant. Before that she was a Student Intern at Sandia National Laboratories from 1992 to 1997.

Shurette will be splitting her time 50-50 between EES and the Theoretical Division. Once her schedule at each office has been arranged, we'll let you know.

Program Notes

EES Division Review Committee (DRC) is Coming

The **EES Division Review Committee** Meeting will be held May 12-14, 2003. You are all welcome to attend the meeting sessions that are open (see agenda at <http://www.ees.lanl.gov/Publications/index.shtml>). The posters will remain up until the 14th of May.

A principal function of the DRC is to **provide assessments** of the quality of division or program's scientific, technical, and programmatic activities to the Laboratory Director and senior management. Other direct DRC benefits to the Laboratory include advice and assistance in identifying new approaches, directions, and opportunities for innovative and expanded research and development programs; peer support for professional activities that support Los Alamos programs; exchange of information both within and external to the Laboratory; and facilitation of Laboratory collaborative relationships with academia, industry, government, and other national laboratories.

Appendix F of the UC management contract with DOE contains nine top-level perfor-

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mance objectives. Associated with each performance objective are a few performance measures. The Laboratory's self-assessment will address each objective using a set of performance assurance metrics. Each objective and measure will have a file that contains the key evidence for the Laboratory's performance. The evidence file for many of the measures will include the **division and program review committee assessments**. EES Division's performance will be assessed against Objective V (see below) mainly and a small piece against Objective II.1, IV, VII, VIII, and IX. These are indicated on the agenda.

The four criteria previously used are **quality of science, relevance, programmatic performance, and technical development**. Over the past several years, EES Division has received a rating of Outstanding / Excellent with a grade of 92-94. b Outstanding / Excellent is equal to the best performing peer community and Outstanding is reserved for clearly world-class work that leads the peer community. Obviously our goal is to reach the “**big O**” and I appreciate the strong efforts of the many people who are contributing to the review and to all of you for your contributions to the Division.

Job Openings

The Job ad for **EES-7 Group Leader has been closed**, and the search committee, led by Greg Valentine, has selected a number of individuals for interview. The job ad for **EES-2 Group Leader is still open** and Craig Pearson has kindly agreed to lead the search committee. That job ad is: <http://www.hr.lanl.gov/JPS/SingleJobAd.asp?ReqNumber=204399&ReqScope=INTERNAL%2FEXTERNAL&ReqTitle=GROUP+LEADER&JobType=UC&JobReopened=N>

Budget Update

Our confirmed budget is now at **\$61.7 Million**. We are doing well in Test Readiness, Ground-Based Nuclear Explosion Monitoring, WIPP, Yucca Mountain, and in the Atmospheric Radiation Measurements Program; we anticipate a few new hires. Our present challenges are in the Nuclear Weapons and Environmental Restoration areas. The Cerro Grande Fire Rehabilitation and the Oil and Gas partnership budgets are scheduled to go to zero in FY-04.

Management Operations and Compliance

As you know, we're trying hard to keep all of our operations up to snuff, and we appreciate your help. This is an ongoing, time-consuming activity. The Group Leaders (GLs) and I are now required to certify compliance on a number of items every month. The GLs and I get lots of notifications that take time and effort for us to resolve – we appreciate your help in avoiding **delinquent status!** (And, of course, our delinquencies are sometimes brought to the attention of my boss.) As of the time of this writing, we have the following operations issues in EES:

Training compliance is at 94 percent, with many of the delinquent training in the area of building and site emergency plans and field-work. Please take note of the reminders that you receive, and take care of outstanding training immediately. Also, my recommendation is that you keep a receipt when you complete training sessions, since the Laboratory's tracking systems are known to lose the evidence. And work with your manager or with **Debbie Pirkel or Jeff Hansen** to delete any training that you no longer need.

We have three individuals who have evidently not submitted their travel returns for trips

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taken in February and March. **Travel returns must be submitted within 30 days.**

We have quite a few issues with items that were ordered (sometimes a long time ago) and apparently not received. If you have any of these unfilled orders, please expedite or cancel the order or reconcile the receipt.

The **Wall-to-wall property inventory** is going well for us, with 93 percent of our items found so far. A lot of the remaining seven percent is property in EES-7 Las Vegas, which has not yet been inventoried. We also have some scattered exceptions throughout the groups, and I have asked Craig Pearson to twist arms to get those items resolved quickly. **We need to reach 99.5 percent for a rating of Outstanding.**

Our managers continue to do at least the required number of Safety and Security walk arounds every quarter, and (with one exception) we have a **perfect record on monthly safety meetings**. This month, thanks to all of you, we also exceeded two years of operations without a lost-time injury! Wow!

Management walk arounds for April

On April 28, I visited with the folks in EES-6 and IGPP who are located in Otowi, TA-3/261.

Service Anniversaries & Congratulations to the Following:

Ted Carney, EES-11 – 5 years
Cecilia Gonzales, EES-11 – 5 years
Mark Peters, EES-DO – 5 years

News from the

Science and Engineering Leadership Team

Manvendra Dubey, Chair,
5-3128, dubey@lanl.gov

Congratulations to **New SELT Members:**

**Mike Ebinger (EES-2),
Chris Echohawk (EES-9), Jeff Heikoop
(EES-6), Lianjie Huang (EES-11),
Bruce Robinson (EES-6), and
Bryan Travis (EES-2).**

It is my pleasure and privilege to inform you that the above EES staff were selected as new members of EES's **Science and Engineering Leadership Team**, with concurrence of the Division Leader. We are all eagerly looking forward to welcome, inform, and engage the new members in our activities that include program development, enhancing LDRDs, empowering TSMs, and gaining recognition of our technical expertise inside and outside Los Alamos.

We all work closely with our Division Leader and his Deputy; we complement the institutional leadership efforts of the Division Leadership Team. In particular, we hope to interface closely with our new Deputy Terry Wallace when he arrives in May and work more closely with the DLT.

I encourage everyone to view our charter and activities at the EES SELT Web site at <http://selt.ees.lanl.gov/>

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Members that will remain on SELT for next year will include:

Jim Bossert, EES-2, Manvendra Dubey, EES-6, (Chair), Paul Rich, (EES-9) (off site for next 3 months), Cathy Wilson, EES-2, and Chris Bradley, EES-11

Our thanks to the following members who are **rotating off** on May 1 after fulfilling their two-year term:

Dave Breshears, EES-2, Paul Johnson, EES-11, Claudia Lewis, EES-9, Rod Linn, EES-2, Steen Rasmussen, EES-6, and Bob Swift, EES-11.

Both the active and senior members who are rotating off will be active in orienting and guiding the SELT. On April 28, Paul Weber welcomed the members and briefed them on his expectations and plans for the future.

Again, we welcome the new SELT members and thank the members who are rotating off for their service. As Chair, I ask that we all put on our Division, Directorate, and Los Alamos' hat and join us in working hard to apply EES science and technology to enhance our national security missions, that definitely include many strong environmental, energy, and earth science components.

Weekly Highlights / Accomplishments sent to ADSR

Carlsbad's Cliff Stroud Named to State Environmental Improvement Board

Cliff Stroud, of Los Alamos National Laboratory's Industrial Business Development Division, was recently appointed to the New Mexico Environmental Improvement Board. The Carlsbad Current-Argus, dated

March 11, 2003, notes that: "Stroud has a background in engineering and public outreach on environmental issues and a keen understanding of the issues surrounding the **Waste Isolation Pilot Plant** and its impact on the community. House Majority Caucus Chairman

John Heaton, D-Carlsbad, states: "Stroud will be a strong voice for protecting the environment in this state and he'll be an advocate for this south-eastern region. He knows the issues here and will make sure our concerns are addressed."

Los Alamos and Berkeley Labs' Poster Wins First Place at IHLRWM Conference

The Tenth International High-Level Radiation Waste Management Conference (IHLRWM) awarded a **First Place** to the poster presentation, "Colloid Facilitated Transport in Fractured Rocks: Parameter Estimation and Comparison with Experimental Data." Authors of the poster are: **Hari Viswanathan, Andrew Wolfsberg** (Los Alamos Earth and Environmental Sciences Division (EES)), Paul Reimus, Doug Ware (Los Alamos Chemistry Division), and Guoping Lu, Lawrence Berkeley Laboratory. The award was made during the Conference Luncheon on March 31 and **Al Aziz Eddebbarh**, Los Alamos, accepted the award for the team. One of the attributions of the presentation that deemed it the "**Best Poster**" is that the science combines modeling and experimental data.

Also presented at the conference was the paper, "Site / Subsite Scale Saturated Zone Flow-Transport Models for Yucca Mountain." Authors of the paper are: **Sharad Kelkar, Peng Tseng, Terry Miller, Rajesh Pawar, Bruce Robinson, George Zvoloski, Edward Kwicklis, Al Aziz Eddebbarh** (all of EES), Arend Meijer (GCX, Inc.), and Bill Arnold (Sandia National Laboratory). The paper was presented during the Saturated

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Zone Flow and Transport session, chaired by Eddebbarh. Kelkar made the presentation in memory of Peng-Hsiang Tseng. Tseng was a technical staff member in the Hydrology, Geochemistry, and Geology Group who unexpectedly died of liver cancer in February. Tseng joined the Laboratory in 1998 and was a respected specialist in computational and experimental hydrology.

Los Alamos Participates in Test Readiness Review

Members of the Geophysics Group, Earth and Environmental Sciences Division, attended a test readiness meeting hosted by the Defense Threat Reduction Agency (DTRA) at the Defense Nuclear Weapons School on Kirtland Air Force Base on March 31 and April 1, 2003. **Christopher Bradley, Wendee Brunish, and Tom Kunkle**, participated in discussions regarding DTRA readiness status, the priorities for weapons effects testing, how to make the best use of DOE and DoD resources, and how to leverage DOE and DoD needs for stockpile stewardship tests and weapons effects tests.

Wendee Brunish provided a progress report briefing to Kerry Kelley and Lt. Col. Horton at United States Stratcom Headquarters in Omaha, Nebraska, on March 27. The report included recent progress producing geologic models with 3-D Computer-Assisted-Design (CAD) format files, and Los Alamos' ongoing work interfacing with DTRA contractor, Advanced Research Applications (ARA). ARA has primary responsibility for developing DTRA's Munitions Effectiveness Assessment (MEA) tool. Also discussed were plans for a Tri-Laboratory coordination meeting in the near future.

On March 26, a meeting was held regarding **Nuclear Weapons Archiving at the Nevada Operations Office** in North Las Vegas for the three weapons laboratories and Bechtel

Nevada. The Laboratories' Progress Reports on FY03 work, discussions on proposed work for next year, and proposed FY04 work were presented. Current work in this area includes compiling data for inventory emplacement holes at the Nevada Test Site, and developing new interfaces for the containment databases.

The Enhanced Test Readiness (ETR) meeting at the Nevada Operations Office in North Las Vegas was also attended by **Wendee Brunish** on March 26. The meeting included discussions on resource loading for ETR, tasks in Major Task Element 5 (MTE-5), and Operations, which includes containment activities. The containment budget for Los Alamos for MTE-5 is approximately \$6M over the next five years. Critical tasks include training and certifying new containment personnel, identifying and testing new stemming materials, and validating new **3-D stress wave and gas flow modeling capabilities**.

Yucca Mountain Tours Office of Inspector General and Others

During the week of March 31 – April 3, **Richard Kovach and Bruce Reinert**, members of the Earth and Environmental Sciences Division, conducted tours for 15 students from Deep Springs College, California (physics students), 15 members of the Clark County Leadership Forum (Las Vegas Nevada), 30 members of the Southern Nevada Retired Teachers Association, and presented a summary of testing activities to members of the Finnish Waste Management Program.

Tours of the site were also conducted for representatives of **Bechtel Science Application International Corporation** (the prime DOE contractor for Yucca Mountain), transportation experts from the Washington DC Office, representatives of the Nuclear Regulatory Commission (NRC) Office of Inspector General, and 104 attendees for the International

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High-Level Radioactive Waste Conference held in Las Vegas, Nevada.

The "tours" consist of a general briefing of the tunnel layout and experiments (both completed and ongoing). This occurs underground in an alcove, a side drift from the main tunnel that was customized specifically for tours (including maps/displays and is about 200 yards underground). The group then boards a train and travels 1.5 miles further underground to observe one of the project's long-term tests and then returns to the surface.

High Tech New Mexico Features Los Alamos Scientists

Douglas ReVelle and Thomas Sandoval, of the Earth and Environmental Sciences Division, were recently interviewed on an Albuquerque, NM radio station (KOB) program, High Tech New Mexico, for an hour on Infrasound technology and on bolides. The scientists will discuss the Laboratory's modern digital measurement systems that are operated by Los Alamos. ReVelle, a meteor physicist, recently was featured in Nature magazine for his integrated spectral, photographic and acoustic data representing more than a dozen large meteoric events. Los Alamos' data is playing a key role in helping scientists to more accurately determine how often the Earth is hammered by giant meteors.

Los Alamos' DOE Fellow Receives AGU Award for Supercomputing Paper

The American Geophysical Union (AGU) for the "Outstanding Student Paper" award selected Glenn Hammond, a DOE Fellow in the Earth and Environmental Sciences Division. Hammond's paper, "Numerical modeling of NAPL Source Zone Treatment," presents very innovative work both in the field of reactive transport and in parallel computing. This was the first time ASCI Q (Los Alamos' supercomputer) was used for

"peaceful" purposes and was among a group of 14 projects selected to use the machine for purposes other than weapons development. The calculation presented was the first of its kind in terms of the size of the problem (over 20 million degrees of freedom), the techniques used in parallel computing involving innovative physics based preconditioning developed in Los Alamos' Theoretical Division, the complexity of the chemical system involved with no assumptions of redox equilibria, and the number of processors used (512 on ASCI Q and using 90 GB of memory). Glenn has an extensive background in computing including FORTRAN90, C, C++, and Java. His areas of expertise are parallel computing and reactive transport. He is a student in the Department of Civil Engineering at the University of Illinois, Urbana-Champaign (UIUC). Glenn's thesis, "Innovative Methods for Solving Multi-Component Bio geochemical Groundwater Transport on Supercomputers," is the result of collaborative efforts with his thesis advisor, Al Valocchi (UIUC), and Earth and Environmental Sciences researcher, Peter Lichtner.

Where's the Water? Sponsored by Los Alamos and NMGIC

Los Alamos National Laboratory will co-sponsor the spring New Mexico Geographic Information Council (NMGIC) meeting on April 24 and 25 in the Los Alamos Research Park. The meeting will examine water resource issues in New Mexico from a Geographic Information Technology perspective. Attendees include speakers from Los Alamos National Laboratory, the University of New Mexico, New Mexico State University, New Mexico State Engineer's Office, US Army Corps of Engineers, Bureau of Reclamation, and the US Geological Survey.

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Yucca Mountain Tours for DOE, DARPA, LLNL, and GAO Visitors

Bruce Reinert, of the Earth and Environmental Sciences Division's Yucca Mountain Project, conducted a tour on April 15 for the Department of Energy (DOE) and Defense Advanced Research Projects Agency (DARPA). DOE attendees include: J. Russell Dyer, Office of Repository Development, Senior Project Advisor; Mark Frei, Deputy Assistant Secretary for Site Closure; and Richard Spence. DARPA representatives from Arlington, Virginia included: Dr. Leo Christodoulou, Program Manager, Defense Sciences Office; Dr. Steven Wax, Deputy Director, Defense Sciences Office; and Dr. Adrian Smith, Associate Director Program Managers and Tactical Technology Office. Also attending the tour was Dr. Joseph Farmer, Lawrence Livermore National Laboratory (LLNL).

A tour was conducted on April 16 by **Richard Kovach**, of the Earth and Environmental Sciences Division's Yucca Mountain Project, for the General Accounting Office (GAO) and attendees included: Tom Kingham, Supervisory Analyst; Dan Feehan, Assistant Director and Natural Resources Environment Issues; Charlane Lecuhga, Senior Analyst, and Lee Carroll, Senior Analyst.

On April 17 **Alan Mitchell**, of the Earth and Environmental Sciences Division's Yucca Mountain Project, conducted a tour for Miriam Crawford, DOE; and Loraine Hanwell, Air Quality Inspector for the State of Nevada.

Los Alamos Presents at Seismic Imaging Science Workshop at Rice University

Michael Fehler, a geophysicist in the Earth and Environmental Sciences Division at Los Alamos, was invited to attend a workshop on April 25 and 26 at Rice University. The work-

shop on seismic imaging was sponsored by the National Science Foundation and focused on research opportunities that may be available for using data collected by a new earth science project called US Array. Among the small number invited, Fehler participated in the discussions and presented a talk titled, "Comparison of Teleseismic Travel-Time Tomography and Teleseismic Kirchhoff Migration Images." The research for Fehler's science was obtained from the **Valles Caldera, New Mexico**. The Valles Caldera is a remnant of the former Jemez Volcano that is about 15 miles west of Los Alamos National Laboratory. The Jemez Volcano reached its height one million years ago and thereafter spewed forth two extremely violent eruptions that emptied its magma chamber. The caldera is almost circular, a cliff-ringed depression, and is 14 miles across with forest covered slopes and canyons.

Earth and Environmental Sciences Division's Yucca Mountain Project Leads Yucca Mountain Tours

Bruce Reinert, of the Earth and Environmental Sciences Division's Yucca Mountain Project, toured the following on April 22: the Association for Financial Professionals that included Peggy Sanders, Vice President, Wells Fargo Bank; Betsy Seifert, Assistant Vice President, Wells Fargo Bank; Teddy McKinnon, Vice President, Wells Fargo Bank; Jeffrey Moore, Vice President, Bank of America; Katherine Hartig, Assistant City Treasurer, Clark County, Nevada; Tonya Dazzio, Senior Investment Officer, Clark County, Nevada; Andrew Artusa, Managing Director, Howarth & Associates; Patricio Zamora, Vice President, Howarth & Associates; and Laura Fitzpatrick, County Treasurer, Clark County, Nevada.

On April 23, **Bruce Reinert** toured John W. Keys III, Commissioner, and Julie L. Bader, Regional Engineer, both from the Bureau of Reclamation.

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Douglas Weaver, Richard Kovach, and Bruce Reinert, led tours and briefings on April 24 for Representative David Hobson (R) Ohio, Chairman of the House Energy and Water Development Appropriations Subcommittee and Assistant Majority Whip; Representative Mike Simpson (R) Idaho, Member House Energy and Water Committee; Representative Marion Berry (D) Arkansas, Member of the House Energy and Water Committee; Robert Schmidt, Overall Staff Assistant, Majority Staff, and Energy & Water Development; Kevin Cook, Staff Assistant, Majority Staff, Energy and Water Development; Dennis Kern, Staff Member, Energy and Water Development Subcommittee; Kenny Kraft, Legislative Director/Appropriations Counsel; and Congressman Hobson's Staff.

Also, on April 24, Richard Kovach and Bruce Reinert toured approximately 100 members from the Schriners Royal Order of Jesters.



image **above**. This is a 75,000-year old scoria cone and it is being used by Los Alamos scientists as an analog “Yucca Mountain volcano.” Analysis of the cone and its surrounding tephra-fall blanket supplies information needed to understand eruption processes and the depths of a conduit formation that would affect an underlying repository.

Read more in the **Progress Report**, page 55, “A New Volcano at Yucca Mountain? What is the Risk?”

Dottie's **Mystery Image for April** (below): what kind of equipment is this?

- LIDAR Equipment?
- Micro Hole Drilling Rig?
- Seismic Detection Monitors?

Respond to: dot@lanl.gov

Winners of the March **Mystery Image**:

1st Place: Dave Vaniman, EES-6
2nd Place: Jamie Gardner, EES-9
3rd Place: Kenny Wohletz, EES-11
4th Place: Carl Gable, EES-6

It was the Lathrop Wells Cone, Nevada!

More About March's Mystery **Image**:

The **Lathrop Wells volcano**, Nevada is viewed from the south in the



Guest Editorial

Natural Analogue Studies at Peña Blanca, Mexico

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Natural analogues provide a line of evidence that supports the understanding of how natural and engineered processes could occur over long time frames and large spatial scales at the proposed Yucca Mountain, Nevada nuclear waste repository. Studies of uranium-series disequilibria within and around uranium deposits can provide valuable information on the timing of actinide mobility and hence the stability of a potential repository over geologic time scales. The Nopal I uranium deposit at Peña Blanca, Mexico, is situated in unsaturated tuff that is similar in composition to the Topopah Spring Tuff of Yucca Mountain and closely matches other evaluation for suitable natural analogues. By modeling the observed radioactive isotope disequilibria at Nopal I, it is possible to estimate the rates of sorption-desorption and dissolution-precipitation of the radionuclides over time. Such information is vital to the testing of and confidence-building in performance assessment models for geologic nuclear waste disposal. Since 1999, Los Alamos National Laboratory and Lawrence Berkeley National Laboratory (under the auspices of the Yucca Mountain Project), in cooperation with the Autonomous University of Chihuahua and the University of Southern California, have been engaged in a study of radionuclide transport at Peña Blanca. Results of this study to date are reported herein.

Background

In the 1970s, the Peña Blanca region, approximately 50 km north of Chihuahua City, was a major target of uranium exploration and mining by the Mexican government, because the region contains numerous uranium deposits. Over the past thirty years, the Nopal I deposit in the Peña Blanca region has been studied by numerous institutions as an analogue for evaluating the fate of spent fuel, associated actinides, and fission products at a geologic repository in fractured, unsaturated volcanic tuff (CRWMS M&O 2000). The Nopal I uranium deposit represents an environment that closely approximates that of the proposed high-level nuclear waste repository at Yucca Mountain in a number of ways: (1) both Yucca Mountain and Nopal I are located in regions of arid to semi-arid climate; (2) both are parts of a basin-and-range horst structure composed of Tertiary rhyolitic tuffs overlying carbonate rocks; (3) both are located in a chemically oxidizing unsaturated zone, 200 m or more above the water table; (4) the alteration paragenesis of uraninite at Nopal I may be similar to the alteration of spent fuel rods in a repository similar to that proposed at Yucca Mountain, according to results of spent fuel alteration experiments (Wronkiewicz et al., 1996).

Earlier studies at Peña Blanca dealt with surface water samples and with bulk samples and fracture-filling materials collected at the +10 level of the Nopal I uranium deposit

(Figure 1 below). These studies, summarized in CRWMS M&O (2000), focused on the extent and timing of uranium-series mobility and transport at this site. Some of these studies reported open-system behavior, suggesting mobility of uranium and its daughter products (e.g., Pickett and Murphy, 1999). In contrast,



Figure 1. View of the Nopal I uranium deposit, Peña Blanca, Chihuahua, Mexico. Terraces are 10 meters apart.

our previous uranium-series thermal ionization mass spectrometry (TIMS) work at Nopal I (CRWMS M&O 2000) found closed-system behavior for many of the long-lived uranium-series members in fracture filling materials. Briefly, the TIMS results indicated that the uranium (235, 238), thorium (230, 232), and protactinium (231) in the fracture-filling minerals have remained stable for more than 300 k.y. at Nopal I. In contrast, we observed open system behavior for radium (226), indicated by loss of radium from the fractures.

Pickett and Murphy (1999) presented measurements of U-Th isotopic composition and concentration in various water samples collected near Nopal I during relatively wet summer conditions. Their observed uranium and thorium concentrations generally correlate with concentrations of major cations and anions and total conductivity, which may reflect evaporation-dilution or rock dissolution effects on all of these species. Thorium and uranium concentrations also correlate strongly with each other, which is surprising given the expected differences in solution chemistry and potential solubility controls for these two elements. Pickett and Murphy (1999) interpreted

these concentrations in the context of solubility control by various uranium silicate minerals (haiweeite, soddyite) and thorianite. They found that a perched water sample was close to solubility for haiweeite, a calcium uranyl silicate mineral. All of the other waters are undersaturated with respect to uranium mineral phases. However, all of the waters are supersaturated with respect to thorianite, which is attributed to the presence of colloidal thorium in the <0.2 μm fraction of these samples. The occurrence of undersaturation for uranium and supersaturation for thorium indicates that radionuclide transport in the unsaturated zone may be controlled by kinetic factors such as evaporation, rock dissolution, and colloid formation, which complicate the interpretations based on thermodynamic (solubility) considerations. The incorporation of kinetic factors is discussed below in regard to the generalized radioisotope transport model of Ku et al. (1992).

Surface Water Sampling

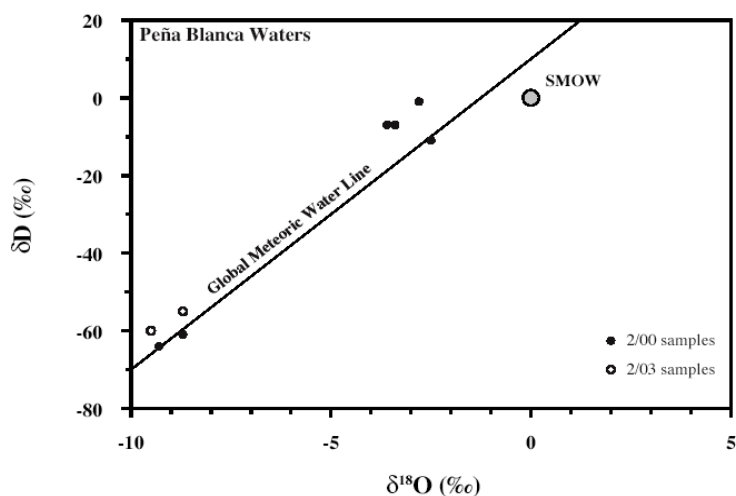
The work of Pickett and Murphy (1999) has been extended to include repeated water sampling at Nopal I, mainly during the dry season. Samples were collected in February and/or March in 2000, 2001, and 2003. These data provide new information on temporal and seasonal variations at the site. As with the previous work, samples are of three different types: (1) perched water trapped in an old borehole about 20 m outside the deposit, (2) seep water obtained from an old adit approximately 8 m below the +10 m surface, and (3) groundwater samples from three wells in the regional carbonate aquifer located 0.6 km southeast of the deposit, 1.3 km southeast of the deposit, and 7 km north of the deposit. In the adit, the water is collected by plastic sheets that funnel into collection bottles where it remains until sampled. The adit is comparatively cool and damp so evaporation effects seem to be relatively small, as confirmed by chloride and bromide measurements. In many cases, the new data

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show higher uranium concentrations ratios than samples collected during the wet season. This could be a result of longer fluid/rock interaction times.

Stable isotope data were obtained for some of these samples in order to evaluate the source and history of the water samples. These data are shown in **Figure 2 below**. When water

of the three-sample cluster. The evolution of stable isotopes for the adit samples appears to have at least three components: 1) evolution of vapor from GMWL, 2) modification by water/rock interaction, and 3) evaporation in the adit collection system (BSC, 2002). We have also measured $^{87}\text{Sr}/^{86}\text{Sr}$ values for many of these samples. These results are consistent with waters derived from a carbonate aquifer.



evaporates, the isotopic composition of the resulting vapor will be shifted to lower values and the residual water will be shifted to higher values on a plot of δD versus δ¹⁸O. The stable isotope data for the wells and a sample from a drill hole into a perched water horizon have significantly lower values than other samples. They fall on the Global Meteoric Water Line (GMWL) and probably represent the average composition for the precipitation at the site. The adit samples all lie much higher on this plot. Of these, three fall significantly to the left of the GMWL and may represent atmospheric water vapor that has diffused into the adit and condensed in the cooler, underground environment. One lies on the GMWL, but probably does not represent a rainwater sample, as it is relatively high for meteoric water at this latitude; it is closer to the opening of the adit and may represent a more evaporated version

The new radium data are notable for the large range of disequilibrium observed. Radium is apparently extremely mobile in the UZ environment directly around the deposit showing large excesses of ^{226}Ra in the adit waters (and generally large depletions in the fracture filling materials noted in our previous work). Conversely, we observe depletion of ^{226}Ra in the borehole and well waters. This can be modeled in terms of rock-water interaction during transport in the SZ.

Note that some of the well waters were collected from holding tanks subject to chemical modification (i.e., evaporation or biological activity). The adit waters are also subject to possible post-collection effects (chemical reactions with solids). This provides more of a basis for the current drilling of new wells and collection of better samples.

Radioisotope Transport Modeling

A model based on naturally occurring uranium- and thorium-series disequilibria is being tested for characterization of the in-situ migration of actinide nuclides in and around the Nopal I uranium deposit. Estimates can then be made of the rates of sorption-desorption, hence retardation factors, and dissolution-pre-

precipitation of the isotopes over a range of time scales, in both saturated and unsaturated zones.

Current models utilizing uranium- and thorium-series disequilibria for radioisotope transport in geologic systems are primarily based on the steady-state assumption (Ku et al., 1992). These models, while elucidating the behavior of radioisotopes in the phreatic zone, may not sufficiently constrain the isotope transport in unsaturated vadose layers where the concentration and transport behavior of radioisotopes are often governed by non-steady-state conditions. Ku and Luo have extended the uranium-series transport model of Ku et al. (1992) to include non-steady state situations. This new, generalized radioisotope transport model has the two important features of being applicable to saturated as well as unsaturated conditions, and providing simultaneous constraints on the behavior of radioisotopes in their dissolved, colloidal, sorbed, and solid pools of a ground-water system. The model provides a means to characterize kinetically controlled radionuclide transport at Peña Blanca.

Seasonal Variability of Uranium Dissolution Rate in UZ

The perched and adit seep waters were sampled during late February 2000 and in early March 2001, in order to assess temporal variations in the transport of uranium in the unsaturated zone. Compared with samples collected during the September wet season of 1995, many of the dry period measurements show much higher ^{238}U concentration and lower $^{234}\text{U}/^{238}\text{U}$, suggesting increased uranium dissolution and/or lower α -recoil associated ^{234}U enrichment rates during dry seasons.

The data collected during the winter dry season depart considerably from the linear relationship between $^{234}\text{U}/^{238}\text{U}$ and $1/^{238}\text{U}$ predicted by the model for the wet season of 1995. Linear regressions on data for the perched and adit seep waters collected during

March 2001 give a ^{234}U α -recoil-related weathering rate (λ_{Pr}) of ~ 5.7 dpm/L/y. Compared to the ~ 9 dpm/L/y for the wet season, this lower α -recoil rate estimate may reflect incomplete flushing of waters through the vadose layers during the dry season. We estimate dissolution rates of uranium to be about 24 dpm/L/y for ^{238}U and ^{234}U (or 136×10^{-9} mol/L/y for ^{238}U and 7.5×10^{-12} mol/L/y for ^{234}U). These rates are about three times higher than those in the wet season, possibly suggesting a favorable physiochemical condition (e.g., increased oxygenation) for uranium dissolution during dry periods. In this context, it should be noted that the samples collected 15 m from the adit entrance show $^{234}\text{U}/^{238}\text{U}$ values lower than secular equilibrium, which suggests dissolution of material previously preferentially depleted in ^{234}U by α -recoil effects.

Large variations in the ^{238}U concentration and $^{234}\text{U}/^{238}\text{U}$ ratio are also found in samples collected from the saturated zone near Nopal I. The effects of mixing will be evaluated in modeling these new data.

Ongoing Studies

As previously summarized, prior work at Peña Blanca contrasts the long-term stability of uranium and thorium in fractures and the ore body against the ongoing dissolution of uranium by surface waters, as evidenced by elevated uranium and ^{226}Ra concentrations and high $^{234}\text{U}/^{238}\text{U}$ in adit seepage waters. The net flux off-site is not well-constrained other than by the 8 m.y. age of the primary uranium mineralization at Nopal 1 (Pickett and Murphy, 1997). The goal of current work is to extend geochemical studies to the third dimension by drilling wells at Nopal I.

Three boreholes around and through the ore deposit are presently being drilled to the water table, at a depth of 240-250 m from the surface. From borehole PB-1, which penetrates the ore deposit, solid core and water samples

are being taken. From the other two boreholes, PB-2 and PB-3, situated approximately +50 m and -50 m from the deposit, cuttings and water samples are being taken. Monitoring wells will be installed to sample ground water on a regular basis.

In addition to the core and fluid samples from the borehole and wells, we will continue to re-sample the perched, seep, and aquifer waters from the sites previously sampled (see above). Where adequate samples can be obtained, we will measure isotopes of U (^{234}U and ^{238}U), Th (^{232}Th , ^{230}Th , ^{228}Th , and ^{234}Th), Ra (^{226}Ra , ^{228}Ra), Po (^{210}Po) and Pb (^{210}Pb) in the fluid samples. We will also study radioactive disequilibria in sorbed phases using leaching methods on the core samples. Since it may be difficult to collect enough fluids from the unsaturated zone for all of the proposed measurements, data on the sorbed phases should provide an alternative way to assess the radionuclide transport in the unsaturated zone.

The U-series modeling effort will be extended to the Th and Ra isotopes. Measurements of Po and Pb isotopes will be applied to the Th model to further evaluate the role of colloids in the transport of these nuclides. The model sensitivity and validity will be tested and ways to evaluate the uncertainties of model parameters will be sought. Results from the Peña Blanca analogue study will be provided for testing the unsaturated zone process model.

Future Work

The Science and Technology program within the Office of Radioactive Waste Management has provided funding for expanded natural analogue studies at Peña Blanca, commencing in 2004. Currently in the planning stages, the enhanced studies will include investigations of colloid transport, saturated zone transport, secondary mineral sequestration, process modeling, and applications to total system performance assessment.

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